Joint
Canada | Alberta
Implementation Plan
for Oil Sands Monitoring

Joint Implementation Plan for Oil Sands Monitoring:

Results Report: 2013–2014

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Preface

This report was prepared by Environment Canada and the Alberta Environmental Monitoring Evaluation and Reporting Agency (AEMERA).

The report presents results of monitoring work done in year two (April 1, 2013 to March 31, 2014) of the Implementation Plan under the joint leadership of Alberta Environment and Sustainable Resource Development on behalf of the Government of Alberta and Environment Canada on behalf of the Government of Canada.

Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA) assumed provincial responsibility for the Joint Canada-Alberta Plan for Oil Sands Monitoring (JOSM) upon the proclamation of the *Protecting Alberta's Environment Act* on April 28, 2014. Since its establishment, the Agency has led the Government of Alberta's contributions and input to JOSM, including the preparation of this report.

This report presents the results of work done and lessons learned from the implementation of monitoring activities in the second year (2013–2014) of the Implementation Plan.

Dr. Karen L. Dodds
Assistant Deputy Minister
Science & Technology Branch
Environment Canada

Mr. Jay Nagendran
Chief Executive Officer
AEMERA

1. Introduction

Responsible development of the oil sands resource is a priority for the governments of Canada and Alberta and needs to be supported by robust, reliable monitoring of the environmental impacts. Monitoring the environmental performance of the oil sands industry has been required by regulatory operating approvals, licenses and permits since industrial extraction began in 1967. With the increased pace and scale of development, and based on recommendations from expert panels, the governments of Canada and Alberta jointly agreed to enhance and integrate existing environmental monitoring to better assess the cumulative environmental impacts of oil sands development.

On February 3, 2012, the federal and provincial environment ministers jointly announced the **Joint Canada/Alberta Implementation Plan for Oil Sands Monitoring ("Implementation Plan")**, committing the two governments to implementing a scientifically rigorous, comprehensive, integrated and transparent environmental monitoring program for the region. The Implementation Plan describes a phased implementation of enhanced monitoring activities over three years (2012–2015), and the rationalization and integration of current monitoring activities into a single, government-led program under the joint management of the two governments. The Implementation Plan also commits the governments to reporting annually on the progress made in carrying out the activities laid out in the Implementation Plan. This report summarizes the progress made during 2013–2014 monitoring program against commitments in the Implementation Plan. Monitoring data, results, evaluation and reports are not described in detail in this report, but references are provided where such detail may be found.

The three-year Implementation Plan seeks to make monitoring of the changes due to oil sands development on the ambient environment more comprehensive, with more compounds sampled at more sites with greater frequency, using established scientific standards and protocols. The results will help to better understand the condition of the environment in the oil sands area, and cumulative environmental effects due to oil sands development activities.

Reporting annually on the progress made in achieving these objectives is a commitment made by the governments of Canada and Alberta to ensure transparency of the work. Reporting for 2013-2014 appears in two parts. The first report (released October 2014) presented the business aspects of the program year, including reporting on Funding, Accountable Administration and Review, Adaptive Management, and comparison of implementation activities against commitments made in the Implementation plan for year two (2013–2014). This second report describes what we have learned from monitoring for the 2013-2014 year. It is expected the annual Business report will be released by June of each year, with the annual Results report released by December of each year.

2. Environmental Effects Monitoring

Monitoring designed to track environmental effects, including cumulative effects of oil sands development, is intended to provide answers to specific ecologically relevant scientific questions. In answering these questions, information becomes integrated, and a picture of the environmental effects of oil sands development begins to emerge. The three-year Implementation Plan is just a beginning, and assembling, evaluating and reporting trends may take some time, particularly where trends and impacts may be subtle.

The primary substances of concern for the Implementation Plan in the oil sands region include: acidifying compounds (NO_x, SO_x); and substances related to the extraction and combustion of bitumen including monocyclic aromatics (BTEX - benzene, toluene, ethylbenzene, xylenes), polycyclic aromatic compounds, naphthenic acids, metals and particulate matter. The quantity of these substances can be estimated from industry emissions reports of their operations (as required under regulations), direct measurements in air, water, groundwater, snow, sediments, soils, and organisms, and from indirect measurements by remote sensing technologies.

Careful monitoring is required since emission concentrations and exposures can vary over time, substances can exist naturally in the environment emissions may be transformed into other substances, may enter or leave the region, or may accumulate locally. At certain concentrations and exposures, some substances may impair the biological functioning of an ecosystem through changes on aquatic and terrestrial plants, fish, amphibians, mammals and/or birds. Monitoring and supporting activities identified in the Implementation Plan are designed to evaluate biological changes at local and regional scales and at different levels in the aquatic and terrestrial food webs. Regular monitoring of a range of indicators of biological species and communities will help identify any potential biological, ecological or toxicological changes.

Oil sands development also physically disturbs habitat (e.g., forests and wetlands) and impacts biodiversity. In the biodiversity component of the monitoring program, monitoring activities will survey a broad variety of mammals, birds, amphibians, invertebrates, and vascular and non-vascular plants and lichens at hundreds of sites with a five-year rotational cycle. Changes to human footprint and habitats caused by disturbance will also be assessed. In addition, there are complementary surveys for rare, at risk and harvested species to improve the ability to detect trends and monitor the impacts of habitat disturbance. This information will provide an improved understanding of the status and trend of species in the oil sands region and indicate the cumulative and individual effects of development on biodiversity, now and into the future.

3. 2013-2014: What We Have Learned In Year 2

Monitoring and scientific study data continue to show evidence that oil sands development is creating low level changes on the surrounding environment. Substances of concern include polycyclic aromatic compounds, particulate matter, acidifying compounds and metals in air, water, biota, snow and sediments. While the concentrations of substances found in the environment are generally not at levels that are cause for concern, monitoring will continue to track, evaluate and report any changes or trends. Generally the concentrations of these substances are highest at locations close to oil sands extraction and upgrading facilities, and they decrease to background levels within roughly 50 km. The biodiversity in the oil sands region remains mostly intact, with a Biodiversity Intactness Index (a biodiversity measure in developed areas relative to undisturbed areas) for the oil sands development area of 91% in the active in-situ region, and 86% in the surface mineable region.

Some specific examples of monitoring observations from the past year include:

- Hourly average measurements of total gaseous mercury made in air in Fort McMurray have not shown significant changes over time, and the observed concentrations are similar to those found elsewhere in Canada.
- Naturally high sediment loads reflecting erosion during the spring and summer cause total metal concentrations in the Athabasca River to exceed the Canadian Council of Ministers of the Environment (CCME) guidelines in these seasons.
- Total phosphorus and nitrogen exceeded the Alberta surface water quality guidelines during periods of naturally high loads of suspended sediment-related precipitation-induced erosion.

- Some wetlands water samples had iron and cadmium concentrations that exceeded established (CCME) safe limits for aquatic life, although there is no spatial pattern associated with proximity to development.
- Some lakes were found to have major ion concentrations that exceeded CCME guidelines, although these observations are consistent with what is known about the underlying geology, with no spatial pattern associated with proximity to development.
- Snowpack data continue to be consistent with past results and show deposition concentrations of PAHs and metals (As, Ag, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Tl, Zn) at low concentrations that decrease with increasing distance from oil sands operations.
- Zooplankton (tiny invertebrates that float freely throughout freshwater) in lake sediments from the oil sands region show increases in primary productivity of biomass that may indicate climate-induced increases in light and temperature, and/or the addition of nutrients.
- Tree swallows from near oil sands operations showed signs of being exposed to atmospheric contaminants yet exhibited normal reproductive success and their nestlings were observed to be healthy.
- Species that prefer old-forest habitat, like the marten, fisher, and bay-breasted warbler, were found to be less abundant than would be expected in an undisturbed area. In contrast, species that thrive in areas with human development, such as the coyote and song sparrow, have higher abundance than would be expected in an undisturbed area.

The data for these results, along with relevant context are all available on the **Portal** and from monitoring organizations such as Wood Buffalo Environmental Association (WBEA), Lakeland Industry and Community Association (LICA) and Alberta Biodiversity Monitoring Institute (ABMI).

INTEGRATING MONITORING RESULTS

Results from two key classes of compounds are summarized below to demonstrate the initial steps in integrating monitoring data from air, water, wildlife health and biodiversity.

Polycyclic Aromatic Compounds

Polycyclic Aromatic Compounds (PACs) are a group of many different substances formed by the incomplete burning of organic substances (oil, gas, wood, food, tobacco, etc.) and are natural components of petroleum deposits. These compounds often attach to dust particles in the air, do not dissolve easily in water, and can be deposited in soils or sediments. Exposure for animals and birds is usually through breathing, although humans may ingest these compounds through consumption of charbroiled foods.

PAC measurements in air, and in air particles, precipitation, snow, bulk deposition, and in sediment cores are being compared to assess and predict the transport and deposition of PACs, including quantifying linkages to potential environmental effects. These data sources include:

TAILINGS PONDS – Concentrations of 16 priority Polycyclic Aromatic Hydrocarbons (PAHs, a subset of PACs) found in tailings pond water suggest that evaporation of PAHs can be a more significant source of atmospheric PAH concentrations than previously recognized. Measuring emissions from tailings ponds has proven to be complex and challenging. Work continues with the industry operators to have better information on potential emissions from the tailings ponds.

AIR – Concentrations of all PACs decreased with distance from oil sands development operations, including for the alkylated-PAHs (a type of PAH generally created in the formation of oil deposits).

SNOWPACK – Snow samples and lake sediment core samples of PACs from 2012 at approximately 90 sites are time-integrated measurements that show concentrations decreased with distance from the major mining extraction and upgrading facilities.

SEDIMENT – PACs in lake sediment cores collected from lakes located 30 to 185 km distance from the major oil sands development area provide evidence of atmospheric deposition of PACs going as far back as 100 years. Lakes closer to oil sands mining activities show PACs deposition has increased over time and can be associated with mining activities. Concentrations are below CCME sediment quality guidelines (where they exist) except in one lake immediately adjacent to the development area and are low compared to semi-rural lakes near Edmonton.

WATER – For samples collected from the Athabasca, Peace and Slave rivers, concentrations of PAHs were generally well below the guideline levels (where guidelines exist).

Additional work is ongoing to determine PAC levels found in benthic invertebrates, colonial waterbirds, waterfowl, and commercially trapped fur bearing animals.

Mercury

Monitoring of mercury is underway to understand if the oil sands industry is a significant contributor of mercury in the region. It is well understood that mercury deposition is a global issue due to the increase in coal-fired power generation in Asia and the transboundary movement of mercury. Mercury can also be introduced into water systems from natural changes in water flows and possible flooding. The monitoring in the region helps to understand the potential human health exposure concerns

and assist health authorities in their assessments. In the oil sands region, mercury is measured in air, snow, water and selected wildlife and compared to assess and predict the transport, deposition, and transformation of mercury, including quantifying linkages to potential environmental changes. These data sources include:

AIR – Total gaseous mercury (TGM) concentrations at select air monitoring sites in the oil sands region are comparable to sites across Canada. TGM concentrations are higher in the spring and midday and low in the fall and early morning. Forest fires tend to increase TGM concentrations, as does long-range transport by wind from the southeast and west. Lower TGM concentrations were generally a result of air transported into the region from the Arctic. The first concentration measurements of the different types of atmospheric mercury are now available and will help elucidate the complex mechanisms of how mercury cycles through the environment through transport, transformation and deposition processes.

SNOWPACK – Monitoring of atmospheric deposition from 2011 to 2013 recorded in snowpack showed low levels of mercury and methyl mercury, comparable to concentrations in undeveloped areas in northwestern Ontario. Concentrations decrease to background at 50 to 100 km from development sites.

WATER – Tributary river water sampling for total and methyl mercury indicates concentrations generally increase during the high flow period (along with other metals). With a few exceptions, levels measured are below guidelines. Future data will indicate whether there is a variation in concentrations along the length of the river.

EFFECTS – In the Peace Athabasca Delta, most colonial waterbird eggs did not show any change in methyl mercury concentrations over the period for which data exists. Methyl mercury in eggs from one species of gull in the Peace Athabasca Delta were found to be slightly higher in 2012 than observed in years earlier. In 2013, mercury levels in western Lake Athabasca were similar to 2012, with the exception of levels measured in the eggs of Caspian Terns. Data suggest that dietary change, long-range atmospheric transport of mercury and forest fire related mercury emissions are not contributing to the observed levels of mercury in gull and tern eggs in northern Alberta. While no applicable guidelines exist for these measurements, expert assessment is that the observed levels of mercury are not likely to pose a risk to these bird populations. Efforts to monitor mercury levels in colonial waterbird eggs continue.

Monitoring mercury in river and lake sediment, invertebrates, fish, amphibians, and hunter-harvested birds and mammals is well underway and data and results will follow.

4. Next Steps

Efforts in 2014–2015 will focus on better technical planning, improving Aboriginal engagement and participation in monitoring, establishing means to better incorporate Traditional Ecological Knowledge, furthering integration efforts, and on developing plans for expanding the geographic scope of the monitoring beyond the initial focus of the surface mineable area.

Technical Annex: Results Update

This document provides a summary of the activities implemented, a description the data available, and internet links to the data undertaken for each 2013/2014 Co-chair approved Work Plan.

"Initial Commitments" are those made by the ministers of Environment for Canada and Alberta in February 2012 in the *Joint Implementation Plan for Oil Sands Monitoring*.

"Actual Commitments" are those made in the approved JOSM 2013-2014 Annual Work Plans.

A1. Ambient Air Quality - Ambient Air Monitoring

Initial Commitment: Continuation and expansion of ambient monitoring network, consistent with the Integrated Monitoring Plan.

Actual Commitment: Existing airshed monitoring – Wood Buffalo and Lakeland airsheds.

Summary of Activities: Wood Buffalo Airshed: Wood Buffalo Environmental Association (WBEA) used 16 continuous monitoring stations to measure from 3 to 10 air quality parameters including CH_4 (methane), CO (carbon monoxide), H_2S (hydrogen sulphide), NMHC (non-methane hydrocarbons), NH_3 (ammonia), NO (nitric oxide), NO_2 (nitrogen dioxide), NO_x (nitrogen oxides), O_3 (ozone), $PM_{2.5}$ (particulate matter 2.5 micrometers in diameter or less), SO_2 (sulphur dioxide), THC (total hydrocarbons) and TRS (total reduced sulphur compounds). A mobile monitoring van measured H_2S, NH_3, NO, NO_2, NO_x, $PM_{2.5}$, O_3, SO_2, THC, wind speed, wind direction, temperature and geographic location on a continuous basis. Three portable trailer-based continuous monitoring stations were purchased and two were deployed. The three trailers were equipped to measure SO_2, H_2S, NO_2, NO, NO_x, THC, temperature, relative humidity as well as wind speed and direction.

The WBEA Human Exposure Monitoring Program (HEMP) monitored odour compound chemical speciation in ambient air, quantitative odour event strength and frequency measurements. In 2013 the Community Odour Monitoring Project and HEMP Portable Air Monitoring Station were implemented.

Lakeland Airshed: Volatile organic compounds (VOC) and polycyclic aromatic hydrocarbons (PAH) were monitored at the Cold Lake South and Portable stations. 24-hour integrated samples were collected every six days in accordance with the

National Air Pollutant Surveillance program. The Portable station was enhanced to collect high NMHC-triggered samples. Canisters were also provided to landowners (trained by LICA) to sample during air quality/odour events.

LICA's core passive monitoring network operated in 2013-14. Samplers were distributed using a 3 x 3 township grid pattern (more densely around oil sands operations) and analyzed on a monthly basis. O_3, NO_2, SO_2, and $H2_S$ were sampled in the passive monitoring network.

Continuous monitoring was carried out in Cold Lake South (Cold Lake South station), southwest of St. Lina (St. Lina station), east of Elk Point (Portable station), and in the immediate vicinity of in situ oil sands operations approximately 10 kilometers southwest of Marie Lake (Maskwa station). Several parameters were monitored including SO_2, H_2S, reduced sulphur compounds, O_3, oxides of nitrogen, total hydrocarbons, particulate matter, and meteorology.

Data Availability and Results: Wood Buffalo airshed data from the 16 continuous monitoring stations are available on the **CASA Data Warehouse** and from **WBEA**. Data are not yet available from LICA's VOC and PAH monitoring Cold Lake South and Portable stations monitoring. Data for LICA's core passive monitoring network and continuous monitoring network are available on the CASA Data Warehouse and from **LICA**. HEMP reports and data are available from **WBEA**.

A2. Ambient Air Quality - Fixed Platforms (now referred to as Ecosystem Monitoring)

Initial Commitment: Installation of three additional ecosystem, transformation and deposition sites in and around the oil sands area, continuation of measurements at 4 existing sites and development of oil sands upwind site.

Actual Commitment: Installation of 3 additional ecosystem, transformation and deposition sites in and around the oil sands area. Enhanced measurements in vicinity of sources, transformation and deposition sites and development of upwind site.

Summary of Activity: Environment Canada added air filter pack measurements to the Island Falls site and made significant progress in the construction of four more regionally-representative sites: Wood Buffalo National Park, NT; Pinehouse Lake, SK; Joussard, AB (upwind site); and Flat Valley, SK.

Island Falls, SK has been collecting precipitation chemistry measurements since October 2012. Enhanced monitoring continued at four existing sites, including total gaseous mercury (TGM) and benzene, toluene, ethylbenzene, and xylene (BTEX) substances at

the sites Patricia McInnes (AMS-6) and Bertha Ganter (AMS-1). Two and a half years of TGM measurements at AMS-6 have been analyzed and the results published. Continuous monitoring of TGM at Lower Camp (AMS-11) was conducted, and monitoring for speciated mercury (i.e., gaseous elemental mercury, gaseous oxidative mercury and particulate-bound mercury) was conducted at Buffalo Viewpoint (AMS-4).

Data Availability and Results: Precipitation chemistry data from the Canadian Air and Precipitation Monitoring Network is available from **JOSM Air Monitoring Data** for use as reference data. Data for total gaseous mercury (TGM) at the Patricia McInnes site (AMS-6) Fort McMurray, Alberta, Esther, Alberta, Bratt's Lake, Saskatchewan, and at the WBEA Lower Camp air monitoring site (AMS-11) are available from **JOSM - Mercury.** Speciated mercury data for the WBEA Buffalo Viewpoint and Fort McKay South monitoring sites are available at **JOSM - Mercury.**

A3. Ambient Air Quality - Monitoring Pollutant Transformation

Initial Commitment: Continue seasonal studies on pollutant transformation

Actual Commitment: No change.

Summary of Activity A ground-based monitoring site (Oski-ôtin) was established in the community of Fort McKay and measurements began in August 2013. Intensive monitoring in the summer of 2013 included airborne components and ground-based monitoring at the Fort McKay South (AMS-13) site. Fort McKay community was given real-time access to raw measurements. Intensive monitoring will help document the emissions, transformation and transport of atmospheric substances in the region.

Data Availability and Results: Airborne measurements from the intensive monitoring are available from **JOSM - Flight Parameters, JOSM - Condensation Particle Number Concentrations, JOSM- Volatile Organic Compounds.** Other airborne data, as well as data from the ground-based monitoring site (Oski-ôtin) in Fort McKay will be made available during the 2014-15 and 2015-16 fiscal years.

A4. Ambient Air Quality - Remote Sensing and Modelling

Initial Commitment: Use remote sensing to produce maps of additional pollutants; use models to produce high-resolution air pollutant maps.

Actual Commitment: Use of remote sensing to produce maps of additional pollutants, and to understand the vertical profiles of pollutants across the oil sands region.

Summary of Activity: The latest NASA sulphur dioxide (SO_2) dataset from the Ozone Monitoring Instrument (OMI) was analyzed. Measurements of methanol, ammonia, and carbon monoxide have also been acquired from the Thermal Emission Spectrometer (TES) satellite instrument and analysis of this data is underway. LIDAR data obtained from Mannix (AMS-5) and Fort McKay South (AMS-13) from the first year of operations were analyzed for impacts of plumes at the ground-level.

Air Quality mapping and analyses in Alberta were substantially expanded and updated to develop a new High resolution Air Mapping tool for the oil sands region. Enhancements include the addition of SO_2 and including periods from January 2004 to September 2014. A report titled **"Satellite Remote Sensing of Air Quality in the Oil Sands Region"** is available.

The Alberta Advanced Air LiDAR was involved in four field campaigns to measure particulate matter (PM), CH_4, and CO_2. Field demonstrations were held at the Edmonton Waste Management Facility, Genesee Power Plant, and Elk Point airport. Emission patterns from industry stacks, and waste management facilities were monitored and characterized.

Data Availability and Results: Satellite monitoring data (and concentration maps) for nitrogen dioxide and sulphur dioxide from 2013-2014 are available (**JOSM - Satellite**). Real-time data for two EC autonomous aerosol LiDAR systems are available by request.

The Air Quality mapping tool will be implemented in 2015-2016. The Alberta Advanced LiDAR data will be processed and available in 2015-2016.

A5. Ambient Air Quality - Focused Studies

Initial Commitment: Studies on odours, degraded visibility, tree rings and fingerprinting data from oil sands specific sources

Actual Commitment: Continued nitrogen and oxygen isotopic fingerprinting from oil sands specific sources

Summary of Activity: Environment Canada and Natural Resources Canada measured the nitrogen and oxygen isotopic signatures of various emissions sources within Alberta to estimate the historical contribution of oil sands emissions to atmospheric deposition and to forests (via tree rings). Air and precipitation samples from the Edmonton/ Fort Saskatchewan area were collected to measure the nitrogen and oxygen isotopic signatures of emissions from refineries and upgraders.

The Monitoring Pollutant Transformation study included Oski-ôtin ground-based monitoring for chemical species that are possible contributors to odour (e.g., reduced sulphur compounds and volatile organic compounds) and visibility issues (i.e., aerosol particles and some gases).

Data Availability and Results: Oski-ôtin data, including compounds important for odour and visibility are available (**Oski-ôtin data - QA/QC Data Oski-ôtin data - Not QA/QC**)

A6. Source Emissions Monitoring - Emissions Inventories

Initial Commitment: Identify gaps in emissions inventories and begin to address information needs

Actual Commitment: No change.

Summary of Activity: A report *Review of Oil Sands Air Emissions* Inventories was finalized and summarized emissions information from a variety of sources to identify overlap, inconsistencies and gaps. In addition, emissions data from the National Pollutant Release Inventory (NPRI) for non-conventional oil extraction in Alberta, along with extraction data from the Alberta Energy Regulator (AER) were compiled for the period of 2002-2012. Progress was made towards incorporating the conventional oil and gas extraction taking place in the oil sands region into the oil sands NPRI inventory.

Data Availability and Results: The report, *Review of Oil Sands Air Emissions Inventories*, will be available during the 2014-15 fiscal year.

A7. Source Emissions Monitoring - Point Sources (stacks and fugitive)

Initial Commitment: Obtain additional point source data to develop/validate emission factors and additional monitoring to address gaps in emissions inventories

Actual Commitment: No change.

Summary of Activity Point source CEMS data for specific sites and time intervals were requested from Alberta Environment and Sustainable Resource Development. Data was processed to identify time gaps and correlation of parameters from the same source (flow, temperature, opacity, concentrations). AER emission upsets records were obtained and compared with measured emission upsets from the aircraft portion of the summer 2013 intensive monitoring campaign.

The aircraft measurements from the summer 2013 intensive monitoring campaign included measurements of emissions from all point and area sources within a mining operation. The measurements were analyzed.

Data Availability and Results: JOSM - Flight Parameters, JOSM - Condensation Particle Number Concentrations, JOSM - Volatile Organic Compounds.

A8. Source Emissions Monitoring - Tailings Ponds

Initial Commitment: Continuation of studies on tailings ponds emissions

Actual Commitment: Continuation of studies on tailings ponds emissions. Development of an autonomous mobile platform for tailings ponds emission monitoring

Summary of Activity: Models estimated that the emissions of 13 priority PAHs (as classified by the United States Environmental Protection Agency) from tailings ponds were a significant fraction of total PAH emissions. Emissions from tailings ponds were also monitored as during flights conducted as part of the summer 2013 intensive monitoring campaign. Measurements of CH_4, NH_3, and CO concentrations at one tailings pond were measured on September 25 and 26, 2013, using two Open Path Fourier Transform Infrared instruments. A prototype GPS guided autonomous mobile platform for sampling substances in air over tailings ponds. The prototype was successfully tested in a lake under windy conditions.

Data Availability and Results: PAH data from one tailings pond, as well as CH_4, NH_3, and CO concentration data for one tailings pond will be available during the 2014-15 fiscal year

A9. Source Emissions Monitoring - Mobile and Area Sources

Initial Commitment: On-board measurement on buses and development of emissions factors for heavy haulers.

Actual Commitment: No change

Summary of Activity: Data from the aircraft portion of the summer 2013 intensive monitoring campaign are being analyzed to investigate the feasibility of separating mobile and area sources.

Data Availability and Results: JOSM - Flight Parameters, JOSM - Condensation Particle Number Concentrations, JOSM - Volatile Organic Compounds. Other data from the airborne and ground-based components of the summer 2013 intensive monitoring will be released when QA/QC is completed.

A10. Deposition - Existing Airshed Monitoring

Initial Commitment: None

Actual Commitment: Deposition monitoring – Wood Buffalo and Lakelands airsheds.

Summary of Activity: Wood Buffalo Airshed: The Forest Deposition Monitoring includes a network of 25 internal stands (longer-term, regionally representative) and 25 edge plots (early warning sites). Insect and disease damage in trees as well as abiotic symptoms on multiple trees at all jack pine forest health site, including the edge sites was completed. This work was conducted by Environment and Sustainable Resource Development with logistical assistance from WBEA. WBEA has created a database management system for all survey data.

Dry Deposition monitors air quality and deposition. Denuder systems were deployed at four existing solar-powered meteorological towers at remote WBEA forest health monitoring sites. Upgrades improved the overall reliability of the system, including winter performance and sampling rates, and the ability to simultaneously monitor sulphate, nitrate and ammonium in particulate matter. A report entitled "Pilot Study Testing of Low-Power Denuder Systems for Measurement of HNO_3, NH_3 and fine particulate sulfate, nitrate and ammonium at WBEA Forest Health Sites", was produced.

The WBEA Passive Monitoring of air quality and deposition at the remote forest health ecosystem sites, co-located with continuous monitoring instruments for validation of the passive measurements. Ambient air passive monitoring included ozone, sulphur dioxide, nitrogen dioxide, nitric acid and ammonia data collected monthly (bi-monthly in winter) at 29 ecosystem sites.

The Ion Exchange Resin deposition (IER) monitoring was further expanded in 2013. Sampling was completed at most sites during the spring and fall changeover campaign. A journal paper interpreting the IER results was produced in 2013.

WBEA conducted continuous ozone monitoring at two remote sites in 2014, in order to continuously measure ambient ozone concentrations (as 1-hour average) at remote forest health sites during the ozone season. The data from this program is currently being analyzed.

WBEA's instrumented meteorological towers sensor replacements and an upgrade of the communication modem have resulted in significantly improved reliability in data transmission. Soil moisture sensors have been replaced with more reliable ones.

Fort McKay Berry Focus Group and WBEA staff collaborated to "twin" traditional and western science indicators. Passive air monitoring sensors were deployed. Field visits

were made June-August to five regional berry patches and berries were harvested by Elders. Analysis for contaminants and health promoting constituents was completed and a validation meeting held on request of Elders.

Lakeland Airshed: No field or laboratory work was undertaken in 2013-14 as this is a 'down-year' in the 4 site sampling program. In 2013-14, ESRD's site at the Cold Lake Fish Hatchery was scheduled to be sampled; LICA's 3 sites in the regional program are scheduled to resume sampling in 2014-15.

LICA adopted the protocol for long term soil monitoring site selection developed by ESRD, and a study to examine and select potential sites for monitoring was initiated in fall 2009. This study began with a review of existing information about the distribution and properties of soils in the LICA study area. Laboratory analyses are completed according to methods applied in the Alberta Environment long term monitoring program. After completion of analyses, all remaining sample materials were archived.

Data Availability and Results: Data and information on the LICA on the long-term soil monitoring program is available from **LICA** and the provincial data repository.

Data and information on the WBEA forest health monitoring, dry deposition monitoring, passive monitoring, remote ozone monitoring, instrumented meteorological towers, and berry health monitoring activities are available from **WBEA**.

A11. Deposition - Ecosystem Exposure Monitoring

Initial Commitment: Measurement of pollutants in ecosystem settings to determine deposition and exposure and measurement of dry deposition flux.

Actual Commitment: No change.

Summary of Activity: Atmospheric concentrations of PACs continue to be measured using passive samplers at 16 sites across the oil sands region. Passive air sampling of PACs adjacent to bird nest boxes to assess exposure was repeated in 2013. Results from the two years of study were analyzed.

In 2013-14, the passive PACs data contributed to a preliminary model estimating deposition of PAHs across the oil sands region, and to assessment of the fate, transport and sources of PACs in the region.

Data Availability and Results: Data from November 2010-June 2012 are available (**JOSM - Deposition**). New data are expected by April 2015.

A12. Deposition - Forest Critical Loads

Initial Commitment: Improve forest critical load exceedance maps

Actual Commitment: No change.

Summary of Activity: 2013-14 was year 2 of a 5-year project to determine and map critical loads of acidity and eutrophication for forest ecosystems in and around the oil sands area. This work will link oil sands emissions and deposition to ecosystem sensitivity/effects. Progress made includes establishing the Critical Load Collaborative Committee, upgrading critical load models and revising national critical load calculations, acquiring and analyzing archived soil samples and gathering existing data sets.

Data Availability and Results: Results from the 5-year project are expected by summer 2016.

A13. Deposition - Enhanced Deposition

Initial Commitment: Continue measurement of polycyclic aromatic compounds and particulate metals at 3 sites and add 2 additional sites.

Actual Commitment: No change.

Summary of Activity: Work was initiated to establish two new sites at the Wapasu Creek and Conklin locations. Site planning and preparation was also started for the Fort McKay/Bertha Ganter and Buffalo Viewpoint sites, both scheduled for completion during the 2014-15 reporting year. Measurements of PACs and particulate metals continued to be made at three sites (Mannix, AMS-5; Lower Camp, AMS-11; and Fort McKay South-AMS-13).

Data Availability and Results: In 2013-14, data for particulate metals at 3 sites (Mannix, Lower Camp and Fort McKay South) are available (**JOSM - Particulate Metals**). Data from active monitoring of PACs will be available in 2014-15.

Peer-reviewed scientific publication: Kirk, J.L., D.C.G. Muir, A. Gleason, X. Wang, R.A. Frank and I. Lehnherr. 2014. **Atmospheric deposition of mercury and methylmercury to landscapes and waterbodies of the Athabasca Oil Sands Region.** Environmental Science And Technology. 48:7374−7383

A14. Deposition - Deposition Modelling

Initial Commitment: Deposition modelling using most recent data

Actual Commitment: No change.

Summary of Activity: The Global Environmental Multi-scale – Modelling Air quality and Chemistry (GEM-MACH) model (2.5 km resolution) continues to generate daily air forecasts of substances in the atmosphere for the oil sands region since October 2012, including sulphur and nitrogen deposition. In 2013-14, forecasts were provided every 12 hours, and the emissions input data were updated. The forecasts were used to inform flight locations in the summer 2013 intensive monitoring campaign. Model output was used to estimate total sulphur and nitrogen deposition to Alberta and Saskatchewan, to calculate exceedances to critical loads for those two provinces, scheduled for delivery in 2014-15.

A15. QA/QC – Air Short Term Study

Initial Commitment: None

Actual Commitment: QA/QC - Air short term study, clean power module for off-grid monitoring stations, evaluation of new technologies

Summary of Activity: The "Joint Oil Sands Monitoring Quality Assurance Guidance" was developed along with training material, including a sample quality assurance project plan, a quality assurance project plan template and a standard operating procedure. This work was built on the jurisdictional review of data quality management procedures conducted by ESRD in 2012-2013.

Data Availability and Results: The guidance document has been circulated among relevant organizations and will be public accessibility in 2015-2016.

W1. Mainstem Water Quality

Initial Commitment: Increase sampling frequency to monthly at specific sites, continue and increase comparability studies and laboratory round-robin and continue to implement items identified in 2011-2012 and 2012-2013 and phase in monitoring of additional sites.

Actual Commitment: As planned plus initiated sampling in the Peace Athabasca Delta.

Summary of Activity: Continued monthly sampling at M4, M5 and quarterly sampling at M3, M6 M7 and water quality parameters were analyzed. Field inter-comparability

studies were continued between Alberta and Environment Canada to assess water quality sampling methods, including cross-channel multi-panel sampling at M4, M5 (monthly), quarterly cross-channel sampling at M3, M6 and M7. Laboratory round-robin inter-comparisons were continued to better assess compatibility of sampling and analytical methodologies with historical approaches. Suspended sediment collection were performed at sites M0, M2, M3, M9 during open water high flow, open water low flow and under ice, along with inter-comparison studies assessing the efficacy of various suspended sediment samplers.

Data Availability and Results: JOSM - Archived Water Quality, JOSM - Mainstem Water Quality

W2. Tributary Water Quality

Initial Commitment: Continue sampling and implement remaining upstream and headwater tributary sites and continue Benthos/CABIN and fish work supporting water quality.

Actual Commitment: Monthly sampling and analysis including: Steepbank, Ells, Firebag, Muskeg, MacKay tributaries, continue Benthos/CABIN and fish work supporting water quality and implementation of remaining upstream and headwater tributary sites.

Summary of Activity: 85% of the total core tributary water quality monitoring sites were sampled as identified in the Phase 1 Technical Plan. 63 tributary sites were sampled in total, with 25 key sites monitored on a monthly basis including those from the Steepbank, Ells, Firebag, Muskeg, and MacKay tributaries. Additional water quality samples were obtained during the autumn tributary benthic macroinvertebrate and fish collections.

Upstream control monitoring sites were added in the Steepbank, Ells and MacKay rivers.

Data Availability and Results: JOSM - Event Based Water Quality.

W3. Athabasca River Tributaries Contaminant Loading

Initial Commitment: Continue sampling and implement remaining upstream and headwater tributary sites and continue Benthos/CABIN and fish work supporting water quality.

Actual Commitment: Tributaries (Steepbank, Ells, Firebag, Muskeg, MacKay) monthly sampling and analysis (Reconcile with EC Tributary Program).

Summary of Activity: Continued monthly sampling at CL2, ST1, MU1, MU4, MU5, MU6, MU7, MU8, JA1, JA2, NM1, FI1, EL1, and MA1. Water quality parameters were analyzed according to Appendix B from the Phase 1 technical plan. Continued co-sampling with Environment Canada at key locations (MU1, MU6, ST1, FI1, EL1, and MA1).

Data Availability and Results: Data are available from ESRD upon request.

W4. Event-based Sampling

Initial Commitment: Continue monitoring program as established

Actual Commitment: Transition from daily to bi-daily to bi-weekly to weekly sampling during the spring freshet, and analysis (Steepbank, Ells, Firebag, Muskeg, MacKay); ongoing post-freshet monthly WQ sampling; add new upstream reference sampling locations to the Ells; maintain automated water quality sondes in the Steepbank, Firebag, and Ells Rivers, and pre-freshet water quality samples; deployment of WQ auto-sampler systems on 4 tributaries

Summary of Activity: Enhanced event-based water quality monitoring was undertaken to better characterize water quality conditions associated with significant hydrological events (e.g., snowmelt, large magnitude rainfall/runoff events). Transitioned from daily to bi-daily to bi-weekly to weekly sampling occurred during the spring freshet periods at 14 sites on the Steepbank, Ells, Firebag, Muskeg, and MacKay rivers. Ongoing post-freshet monthly water quality sampling was conducted for all the identified tributaries. In addition, new upstream sites were added and sampled monthly (Ells Riff2, Ells Riff5, Mackay MA5, Steepbank Riff10). A network of automated YSI water quality sondes were maintained at 13 sites in the Steepbank, Firebag, MacKay and Ells Rivers, which provided continuous, real-time measurements of pH, dissolved oxygen, temperature, specific conductivity, turbidity. A network of water quality auto-samplers were installed at 6 sites in the Steepbank, Muskeg, Ells rivers to capture water quality changes during high rainfall and runoff events.

Data Availability and Results: JOSM - Event Based Water Quality.

W5. Expanded Geographic Extent (PAD; Slave River; Lake Athabasca)

Initial Commitment: Continue sampling and implement up to 10 additional sites.

Actual Commitment: Implement sampling up to 10 additional sites (wetland sites in the PAD).

Summary of Activity: 80% of sites that are to be in place under full implementation by 2015 were sampled, with 55% at monthly frequency. Monthly surface water quality samples were taken at 12 sites in the expanded geographic area (M9, M10, M11a, M12, BI1, BU1, BU2, MC1, RI1, QU1, SL1, SL2). Deployed passive samplers monthly in open water at three sites (M9, M11a, M12). Automated water quality samplers were deployed at two sites for two months each (M9, M11a).

Data Availability and Results: Data are available from **JOSM - Expanded Geographic Extent Water Quality** and historical data at **JOSM - Archived EGA Water Quality**

W6. Passive Sampler Program

Initial Commitment: Increased number of sites to full implementation and increase sampling frequency

Actual Commitment: No change

Summary of Activity: Completed monthly deployments and retrievals of passive water samplers at mainstem sites M0, M1, M4, M7 and M9 (and on the Slave and Peace rivers as part of Extended Geographical Area), and initiated monthly sampling at M3. Implemented passive suspended sediment sampling with monthly deployments (M0, M2, M3, M4, M7 and M9). Deployed and retrieved passive samplers on the Steepbank, Ells, Mackay, Firebag, Dover, Jackpine and Birch rivers. Deployed and retrieved passive sampling devices in deltaic wetlands in mid-summer in the Peace-Athabasca-Delta.

Data Availability and Results: Data not yet available.

W7. Oil sands contaminants source identification

Initial Commitment: None

Actual Commitment: Ongoing development and implementation of analytical methods for identification of unique oil sands chemical components for purposes of source identification.

Summary of Activity: Continued utilizing chemical/toxicological evaluations of oil sands acids (via distillation and fractionation of bulk oil sands process water extracts from different tailings ponds). Completed chemical profiling of regional groundwater samples for oil sands contaminants.

Data Availability and Results: Data not yet available

W8. Groundwater Quality

Initial Commitment: Continue monitoring program as per Baseline year.

Actual Commitment: Further assess/quantify surface groundwater interactions and continue assessment of groundwater proximate to tailings ponds and continue monitoring of existing NAOS network and establish SAOS GW Network.

Summary of Activity: Surface/Groundwater interaction studies were performed on the Mackay, Steepbank, Ells, Athabasca and Clearwater Rivers. Potential groundwater discharge locations were identified in MacKay River; explored direct measurement of groundwater discharge to the river (seeps) to quantify net groundwater input in selected reaches of the Steepbank and Ells rivers. Collected water chemistry samples from 19 sites along the Athabasca and Clearwater rivers. Collected 23 large-volume groundwater samples across the lower Athabasca region for background geochemistry and four from Pond 1/Ells River for Toxicity Identification Evaluation (TIE) analyses. Completed a validation study of multi-marker approach for identifying Oil Sands Process Water (OSPW) in groundwater. Sampled deeper groundwater seeps from Devonian carbonates on the Athabasca mainstem and its tributaries to compare against shallow groundwater contributions and to assess the relative importance of groundwater contributions to the Athabasca River.

Monitoring of NAOS (north Athabasca oil sands) network continued to be funded by ESRD, independent of the Joint Oil Sans Monitoring Program (JOSM).

Data Availability and Results: JOSM - Groundwater Water Quality. Data collected by ESRD in the NAOS are available through ESRD, upon request.

W9. Surface water quantity and sediment transport

Initial Commitment: Mainstem: Consider new hydrometric station at a key location to be determined. Tributary sites and Expanded Geographical Extent: Add additional tributary hydrometric measurement coincident with water quality monitoring sites, as per the Integrated Monitoring Plan.

Actual Commitment: Mainstem: Monitoring sediment dynamics/ transport/chemistry in tributaries; river sediment quality sampling and analysis (RAMP); and bed sediment/ bedload bathymetric mapping. Tributary sites and Expanded Geographical Extent: RAMP/Hatfield Field Activities: Management, QA/QC, reporting and audit of RAMP stations to verify data comparability

Summary of Activity: Eight Athabasca river hydrometric stations were changed to annual (year-round) from seasonal (open water period) operation. Water Survey Canada

also assessed the installation of new hydrometric station at M9. In addition, an audit was conducted on existing RAMP hydrometric sites to ensure that data are collected using Standard Operating Procedures and conform to WSC standards.

Initiated development of a continuous sediment flux program, initial sampling at M3. Additional sediment cores were taken from six lakes in March 2013. Bulk suspended sediment samples were taken from the Athabasca and Steepbank Rivers to assess sediment quality and sediment physical characteristics. Completed time integrated suspended sediment sampling from Athabasca mainstem (winter only, under-ice at M0, M2, M3, M9) and Ells and Steepbank rivers. Bathymetry information was added to Habitat Mapping Surveillance Program. Completed a 60km swath bank to bank between Fort McMurray and HWY 63 bridge and additional swaths to M7. Sites M3, M4 and M5 were re-swathed for year to year comparison. Constructed sediment rating curves for Athabasca and tributaries of suspended loads to use as boundary conditions in sediment transport model

The "management, QA/QC, and reporting" portion of the 2013-14 program delivered by Hatfield Consultants contributed to the publication of the 2013 RAMP report, and to the finalization of the data. This item refers to activities that are common to individual projects delivered by Hatfield Consultants.

Data Availability and Results: Surface Water Quantity and Sediment Transport **EC Water Quantity Monitoring**, Real-time hydrometric data **EC Real-time Water Quantity Monitoring, RAMP Report, RAMP**

W10. Modelling (formerly River Ice Modelling)

Initial Commitment: Implement up to 8 more sites on the Athabasca mainstem; increase monitoring frequency

Actual Commitment: Hydraulic and hydro-climatic modelling; and analysis of changes in regional hydro- climatology (activity linked to Water Quantity). Further develop hydro-climatic, hydrologic, and hydraulic models for prediction of water quantity and quantity and sediment transport, and model sediment dynamics within selected tributaries relates to REPS below) – complete Ells River model; initiate Steepbank model.

Summary of Activity: Sediment Transport/Dynamics - completed the development of an Ells River model and initiated validation procedures; initiated model development for the Steepbank River, including sediment deposition and erosion characterization. Two annular flume experiments were conducted as input to numerical models of sediment transport for the Steepbank River model. Completed active suspended sediment collections at sites M0, M2, M3, M9 during open water high flow and low flow and under ice.

Hydrological and Climatic Modelling – compiled and initiated assessments of multi-year, historical climate and hydrological data, assessed hydro-climatic variability and extremes and initiated development of related water availability models.

Hydraulic Modelling - completed initial 1D numerical model of flow and sediment transport in the Lower Athabasca River (LAR) (250Km from Crooked Rapids to Old Fort), completed initial 2D numerical model of flow and sediment transport in the LAR and a focus on a 20Km reach above and below Steepbank River – EFDC (common platform between EC and Alberta). Initial modelling of sediment and contaminant transport in Mainstem (near Steepbank River) and tributaries was completed.

Data Availability and Results: Surface Water Quantity and Sediment Transport **EC Water Quantity Monitoring,** Real-time hydrometric data EC **Real-time Water Quantity Monitoring.**

W11. Sediments

Initial Commitment: Benthos/CABIN and fish work to generate supporting sediment quality data. New mainstem hydrometric station indicated to collect sediment samples, continue mainstem historic method sediment sampling, expand sediment sampling at mainstem sites, full scope of sampling of sediment cores from small lakes implemented, and process-based sediment monitoring in mainstem/tributaries; implement remaining sites.

Actual Commitment: Monitoring sediment dynamics/ transport/chemistry in tributaries; river sediment quality sampling and analysis (RAMP); and bed sediment/bedload bathymetric mapping.

Summary of Activity: Continued sediment quality sampling with benthos/CABIN and fish work to provide greater geographical coverage. Initiated development of a continuous sediment flux program, initial sampling at M3. Additional sediment cores were taken from six lakes in March 2013. Bulk suspended sediment samples were taken from the Athabasca and Steepbank Rivers to assess sediment quality and sediment physical characteristics. Completed time integrated suspended sediment sampling from Athabasca mainstem (Winter only, under-ice at M0, M2, M3, M9) and Ells and Steepbank rivers. Added bathymetry information to Habitat Mapping Surveillance Program. Completed a 60km swath bank to bank between Fort McMurray and HWY 63 bridge and additional swaths to M7. Re-swathed M3, M4 and M5 for year to year comparison. Constructed sediment rating curves for Athabasca and tributaries of suspended loads to use as boundary conditions in sediment transport model.

Data Availability and Results: Surface Water Quantity and Sediment Transport **EC Water Quantity Monitoring.** Real-time hydrometric data **EC Real-time Water Quantity Monitoring.** River sediment quality analysis on samples collected at RAMP benthic invertebrate sampling sites according with procedures described in the 2013 RAMP report and Appendices. The sediment quality data were reported in the 2013 RAMP report and are available on from **(RAMP)**

W12. Mainstem Benthic Invertebrates

Initial Commitment: Mainstem – Continue all sites

Actual Commitment: No change.

Summary of Activity: Continued sampling 11 sites (from M0 down to M9) and retrieved all available historical benthic data to assess spatial and temporal trends. The benthic invertebrate bioassessment of the Athabasca River is being conducted through an integrated analysis of historical biological and physio-chemical information, GIS data and contemporary field sampling. Assessments of the response indicators (benthic invertebrates, sestonic and benthic chlorophyll, benthic algae for taxonomic identification) were undertaken at all benthic sampling sites. Additional water samples were taken from each site and analysed to relate water quality to ecological condition. Tissue samples from sentinel benthic invertebrates (e.g., dragonflies) were collected to assess patterns of mercury bioaccumulation in the benthic food web.

Data Availability and Results: JOSM - **Mainstem Benthic Invertebrates**

W13. Tributaries Benthic Invertebrates

Initial Commitment: Biota/WQ/Sediments implementation of sites as per Plan at the increased sample frequency; implement up to 30 additional sites focusing on enhanced coverage of reference locations

Actual Commitment: Tributary CABIN sampling (fall 2013) and interpretation of 2012 data and chemical analysis, benthos and sediment sampling, analysis and reporting at 38 sites; RAMP benthos and sediment sampling, analysis and reporting.

Summary of Activity: 60 tributary sampling reaches were sampled following full CABIN protocols, including 25 tributary reaches for sampling method inter-comparison studies. Available historical benthic data was compiled to facilitate the assessment of historical spatial and temporal trends. Assessments of the response indicators (benthic invertebrates, benthic chlorophyll) were undertaken at all benthic sampling sites. Water samples were taken from each site. Benthic invertebrate community assessments in both erosional and depositional zones were initiated at select sites.

In 2013-14, the Regional Aquatics Monitoring Program was still operating independently under the JOSMP, with funding provided directly from industry. The Benthic Invertebrate component included field surveys, management, QA/QC, and reporting for all sites. Sampling was conducted in September 2013. All data collected during the 2013 calendar year were analyzed, with results provided in the 2013 Technical Report. Progress was made to address differences in sampling methodologies between RAMP and EC for benthic invertebrates through comparison studies on some tributaries.

Data Availability and Results: JOSM - **Tributary Benthic Invertebrates; RAMP**

W14. Extended Geography - Deltaic Ecosystem Health

Initial Commitment: Biota/WQ/Sediments complete implementation of all sites as per Plan at the increased sample frequency

Actual Commitment: No change.

Summary of Activity: Seasonal (spring, summer, autumn) sampling was conducted at 12 Peace Athabasca Delta sites + 6 Slave Delta sites for invertebrates, water quality and sediments at the increased frequency from annual. Representative PAD wetlands were instrumented in April/May to measure year-round water temperature, dissolved oxygen, water balance, hydro-period and connectivity to main flow system. Enhanced field surveys of surface elevation and bathymetric characteristics at study sites were undertaken using ground and aerial methods.

Data Availability and Results: EC - **Deltaic Benthic Invertebrates** Historical data: EC - **Archived Benthic Invertebrates.**

W15. Snow and Atmospheric Deposition

Initial Commitment: Continue monitoring all snow sites and wet precipitation sites co-located with three WBEA sites.

Actual Commitment: No change.

Summary of Activity: Snowpack was sampled at approximately 130 sites were to measure atmospheric deposition of total mercury, methyl-mercury, heavy metals and lithogenic elements, unsubstituted and alkylated PAHs. Related water quality parameters obtained from melted snow include nutrients and sulphate. Paleo-coring was conducted from 6 regional lakes. Black carbon and chlorophyll levels were quantified in lake sediments along with cladoceran, midge and diatom remains. Additional snow sites in downstream environments were identified and sampled by the Mikisew Cree First Nation.

Data Availability and Results: JOSM - Snowpack and JOSM - Lake Sediment Cores

Peer-reviewed science publication: J. Kurek, J.L. Kirk, D.C.G. Muir, X.Wang, M.S. Evans, J.P. Smol. 2013. **Legacy of a half century of oils sands development recorded by lake ecosystems.** Proceedings of the National Academy of Sciences. 110:1761–1766

W16. Wild Fish Health

Initial Commitment: Mainstem: all sites fully implemented by Year 2 and for tributaries: All sites fully implemented by Year 3.

Actual Commitment: Mainstem: Monitor 6 sites (fall) and for tributaries: Monitor 10 sites river-reaches on 6 tributaries.

Summary of Activity: 6 Athabasca River mainstem sites (from M0 to M9) were sampled in late summer, early autumn for sentinel large-bodied (longnose sucker) and small-bodied (trout perch) sentinel fish species. 13 tributary sites were sampled for small-bodied fish (slimy sculpin) in the MacKay, Steepbank, Ells, Dover, Muskeg, Firebag, High Hills, Horse, Dunkirk and Alice Rivers. Measurements included age, body weight, gonad size, condition, and liver size following Environmental Effects Monitoring protocols.

Data Availability and Results: JOSM - Wild Fish Health.

W17. Wild Fish Communities

Initial Commitment: Mainstem & tributaries – all sites fully implemented at existing frequency

Actual Commitment: Tributary/Mainstem and lake fish inventories; fish contaminants; management/QC&QA/reporting.

Summary of Activity: RAMP monitored the wild fish communities of tributaries (37 sites once/year) and the Athabasca River mainstem (16 sites 3 times/year). Wild fish health was monitored at 5 sites in the Athabasca River mainstem and fish tissue was collected for mercury analysis in Christina and Gregoire lakes. This program examined potential contamination of sport fish species and in conjunction with index netting conducted by ESRD. Activities included field surveys, data management, QA/QC, and reporting for all sites. All data collected during the 2013 calendar year were analyzed, with results provided in the 2013 RAMP Technical Report. Efforts to align RAMP fish monitoring activities under JOSM were completed. Mikisew Cree First Nation provided local guides for fish sampling in the Athabasca River Delta.

Data Availability and Results: RAMP - Fisheries

W18. Fish Toxicology

Initial Commitment: Tributaries – sampling program to continue. Snow – current snow sites. Ponds – ponds, seeps and groundwater to be determined.

Actual Commitment: Assess toxicology of oil sand related contaminants on fish/ invertebrates

Summary of Activity: Completed laboratory fish and invertebrate bioassays to assess the toxicity of river waters, sediments, suspended sediments, groundwater, depositional samples (snow) and erosional samples (freshet).

Data Availability and Results: Data to be released shortly.

W19. Riverine In-situ Bioassays

Initial Commitment: Continue sampling program

Actual Commitment: Assess toxicology of oil sands related contaminants on invertebrates

Summary of Activity: Caged mussels (1 month - 9 tributary and mainstem sites) and Hyalella (2 weeks - 9 tributary sites) were assess for toxicology after being place in the natural environment.

Data Availability and Results: JOSM - Caged Hyalella. Data for caged mussels will be made available in the 2014-2015 reporting year.

W20. Lake Health (Fish/Invertebrates)

Initial Commitment: Continue sampling program

Actual Commitment: Tributary/Mainstem fish inventories; fish contaminants; management/QC&QA/reporting

Summary of Activity: This program examined potential contamination of sport fish species and in conjunction with index netting conducted by ESRD.

The Fish Health component included field surveys, management, QA/QC, and reporting for all sites. All data collected during the 2013 calendar year were analyzed, with results provided in the 2013 RAMP Technical Report. Efforts to align RAMP fish monitoring activities under JOSM were completed. Mikisew Cree First Nation (MCFN) provided the local guide for fish sampling in the Athabasca River Delta.

Data Availability and Results: RAMP - Fisheries

W21. Acid-Sensitive Lakes

Initial Commitment: Monitor 300 sites or more. Align work under RAMP with results from assessment and lake surveys. Conduct additional tiered samples of lake systems as informed by previous years' status and trends analysis.

Actual Commitment: Align work under RAMP with results from assessment and lake surveys. Assessments of 2012-13 lake data to support long-term lake monitoring design/planning. Conduct surveys of lakes in NE Alberta, NW Saskatchewan, and southern Northwest Territories to identify additional lakes for long term acid deposition monitoring.

Summary of Activity: 2013-2014 commitments met. Assessed nearly 350 lakes sampled in 2012-13 to inform selection of the level 2 and level 3 lakes to be monitored. A lake survey database (inclusive of field observations and chemistry data from nearly the 350 level 1 lakes) was produced. Added 22 RAMP lakes to the network of acid sensitive lakes being monitored. Sampled Level 2 lakes in Alberta, Saskatchewan, and Northwest Territories, continued baseline characterization and initiated paleoecological analyses. Selected Level 3 lake ecosystems in Saskatchewan, continued evaluation of candidate lakes in Alberta for Level 3 intensive monitoring, and began instrumentation of selected lakes.

In 2013-14, the Regional Aquatics Monitoring Program was still operating independently under the JOSMP, with funding provided directly from industry. The Acid-Sensitive Lakes component included the management, QA/QC, and reporting on 50 lakes that were sampled by ESRD to assess acid-sensitivity. Sampling took place in August 2013. All data from the August sampling program were analyzed, with results provided in the 2013 Technical Report that was released in April 2014. Data were released on the RAMP public website in May 2014.

Data Availability and Results: JOSM - Acid Sensitive Lakes\Level 1 Surveys, JOSM - Acid Sensitive Lakes\Level 2 Temporal monitoring and **RAMP - Acid Sensitive Lakes**

W22. Representative Sub-basin Studies (REPS)

Initial Commitment: Examine other potential REP candidates; ongoing analyses/sampling.

Actual Commitment: Representative Sub-basin Studies (REPS)/ Process Integration/Modelling.

Summary of Activity: Representative Sub-basin Studies includes focused integrated monitoring, process studies, and modelling to assess and predict casual linkages

of oil sands operations to observed effects. Eight REPS sites were established: 4 on the Steepbank; 3 on the Ells; 1 river reach of the Athabasca Mainstem below Fort McMurray. Measurements were made (sediment transport/dynamics, fish and invertebrate health, water quality parameters, water quantity (flows), sediment quality parameters, in-situ toxicology, etc.) at identified locations.

Data Availability and Results: Data is not yet available.

W23. Mainstem – paired buoys

Initial Commitment: Continue buoy deployment during open-water season. Add future instrumentation as feasible

Actual Commitment: Continue buoy deployment during open-water season.

Summary of Activity: Deployed two river platforms with multiple water quality, at two sites (M9, M11a) during the open-water season (June-October). Residents from Fort Smith helped maintain one of the river platforms. Less than one week after deployment the M11a platform was heavily damaged by floating debris, causing the platform deployment program to be suspended. An alternative automated monitoring program was implemented in its place.

Data Availability and Results: Data not yet available.

WT1. Colonial Water Bird Health and Contaminants

Initial Commitment: Gulls and Terns: Eggs collected at least at the following locations: Rocky Point (WBNP), Mamawi Lake (WBNP) and Egg Island (Lake Athabasca).

Actual Commitment: No change.

Summary of Activity: Eggs were collected and analyzed for contaminants from Egg Island (Lake Athabasca) and from Mamawi Lake in Wood Buffalo National Park. Data were compared with previous results. Prey fish were collected near the nesting sites of these birds in the Peace Athabasca Delta.

Aboriginal communities from Fort Chipewyan have been involved in reconnaissance efforts and the collection of gull and tern eggs. The community-based monitoring program in Fort Chipewyan (members include the ACFN, MCFN, and Métis representatives) aided in the collection of prey fish for mercury analysis. Results of this monitoring activity have been presented to the community. Identification of potential new gull and tern colony sites for 2014 sampling was completed in 2013/14. TEK contributed to the identification of certain waterbird colonies in the Peace Athabasca Delta.

Data Availability and Results: JOSM - Wild Bird Health and Contaminants.

Peer-reviewed science publications: Hebert, C.E., D. Campbell, R. Kindopp, S. MacMillan, P. Martin, E. Neugebauer, L. Patterson, and J. Shatford. 2013. Mercury trends in colonial waterbird eggs downstream of the oil sands region of Alberta, Canada. *Environmental Science and Technology* 47:11785-11792.

WT2. Insectivorous Bird Health and Contaminants

Initial Commitment: Swallows: Eggs collected at least at the following locations: N and S of Fort McKay, S, N of Fort McMurray (reference)

Actual Commitment: No change

Summary of Activity: This project has been deferred.

Data Availability and Results: No data are available.

WT3. Amphibian Health and Contaminants

Initial Commitment: Amphibian samples were collected from ponds in the Fort McMurray area and from ponds over an expanded geographical area with continued monitoring at 2 sites in NWT and various sites in Alberta (up to 40 ponds).

Actual Commitment: No change.

Summary of Activity: Amphibians and water samples were analyzed for contaminants from wetland sites inside and outside of the oil sands region (16 sites) were analyzed for contaminants. The prevalence of two infectious amphibian diseases and the rate of malformations were assessed at all sites. Semi-permeable membrane devices were also installed at select wetlands (5) and used to monitor PAHs over a period of 40 days. Amphibian population health indicators and general wetland characteristics were assessed at all sites. Reconnaissance for new amphibian breeding sites suitable for long-term monitoring was completed.

Traditional ecological knowledge was important in identifying wood frog breeding locations in the northern reaches of the study area, including the Peace Athabasca Delta and the NWT.

Data Availability and Results: Metadata for monitoring collection sites are available (see Amphibian Contaminants sites on the interactive map). Water chemistry data and water metals concentration data (collected from 2011 to 2014) are available **JOSM - Amphibian Health and Contaminants.**

WT4. Laboratory Exposures and Effects

Initial Commitment: Assessing impacts of water quality on amphibians using pond water, snow melt, and *in situ* exposures.

Actual Commitment: Assessment of the exposure and effect of oil sands-related contaminants, using sediment exposures, and wood frog (*Lithobates sylvaticus*) tadpoles, as well as a surrogate amphibian species.

Summary of Activity: Wetland sediments collected near development sites and at remote sites were analyzed for heavy metals, PAHs and NAs. Laboratory exposures of amphibians to collected sediment were conducted. In one laboratory, uptake and depuration of PAHs was assessed using wood frog tadpoles. Data analysis from 2013 sediment exposures and planning for further studies is on-going.

Data Availability and Results: Data are currently not available.

WT5. Bird Health and Toxicology - Laboratory Exposure and Effects – Air Emission

Initial Commitment: Exposures of laboratory birds to VOCs and SO2.

Actual Commitment: Using exposures of captive birds (quail, kestrels) in the laboratory to assess possible adverse effects of VOCs and SO_2 on the health of individuals.

Summary of Activity: Captive Japanese quail and American kestrels were exposed to volatile organic compound and oxidizing agents, specifically benzene, toluene, NO_2 and SO_2. The efforts of the birds to detoxify was assessed by measuring the activity of the enzyme 7-ethoxyresorufin O-dealkylase (EROD). A measure of stress, plasma corticosterone, was also assessed. Neither species showed alteration in immune function measures, in immune organ mass, or in the histology of the immune organs.

Data Availability and Results: Data will be available in the spring of 2015.

Published peer-reviewed paper: Smits, J.E.G. and K.J. Fernie. 2013. **Avian wildlife as sentinels of ecosystem health.** Comparative Immunology Microbiology and Infectious Diseases. 36:333-342.

WT6. Field Exposure and Effects – Air Emissions / PAHs

Initial Commitment: Nest boxes installed radially around three processing plant and in reference location.

Actual Commitment: No change.

Summary of Activity: Tree swallow nest boxes and passive air samplers were installed at two sites impacted by nearby oil sands extraction and processing activities, and at a relatively undisturbed reference site south of Fort McMurray during the spring and summer of 2012 and 2013. The air samples revealed elevated levels of organic substances, including PAHs, alkylated PAHs, and dibenzothiophenes at the oil sands study sites relative to the reference site. Biological measurements in the birds (e.g. whole body and organ morphometric data, immunological measurements, enzyme activity, reproductive success etc.) were made in 14 day old tree swallow nestlings. No impact on reproductive success was observed.

Data Availability and Results: JOSM - Avian Toxicology. In the Peace Athabasca Delta, most colonial waterbird eggs did not show any change in methyl mercury concentrations over the period for which data exists. Methyl mercury in eggs from one species of gull in the Peace Athabasca Delta were found to be slightly higher in 2012 than observed in years earlier. In 2013, mercury levels in western Lake Athabasca were similar to 2012, with the exception of levels measured in the eggs of Caspian Terns. Data suggest that dietary change, long-range atmospheric transport of mercury and forest fire related mercury emissions are not contributing to the observed levels of mercury in gull and tern eggs in northern Alberta. While no applicable guidelines exist for these measurements, expert assessment is that the observed levels of mercury are not likely to pose a risk to these bird populations.

Published peer-reviewed paper: Cruz-Martinez et al., 2014. Detoxification, endocrine, and immune responses of tree swallow nestlings naturally exposed to air contaminants from the Alberta oil sands. *Sci. Total. Environ.* 502(2015), 8-15.

WT7. Dead and Moribund Bird Contaminants and Toxicology

Initial Commitment: Birds collected from tailings ponds near Fort McMurray (event-based).

Actual Commitment: No change

Summary of Activity: Frozen carcasses of 28 waterfowl that had come into contact with oil sands tailings ponds were retrieved from various oil sands companies. These comprised mostly of mallards, common goldeneyes, and green-winged teals. Dissection and subsequent toxicological assessments on these birds are planned in 2014-2015.

Data Availability and Results Bitumen covered waterfowl carcasses are currently in storage pending dissection and analyses.

WT8. Hunter/Trapper Harvested Wildlife Contaminants and Toxicology

Initial Commitment: Mallards, otters harvested/ trapped at locations in NWT and northern Alberta. Target sample of 20 animals at each location and up to 100 mallards and 60 otters processed for contaminants and toxicology.

Actual Commitment: Dissection and analysis of hunter/trapper harvested animals for metals, PAHs, and NAs.

Summary of Activity: Approximately 600 mammal carcasses were obtained from local hunters and trappers. Species include: American marten, fisher, Canada lynx, river otter, beaver, muskrat, mink, moose, white-tailed deer, wolverine, and fox. Also, 104 mallard ducks from areas north (Peace Athabasca Delta, AB and the Slave River Delta, NWT) and south (west to east transect across Alberta and the area surrounding Lac La Biche) of the oil sands region were obtained from local hunters.

Local First Nations and Métis people recommended muskrats to be studied. Community members were actively involved in site selections and wildlife collections. Linkages to community-based monitoring programs allowed for standardized operating protocols to be implemented in the collection and post-mortem evaluations and dissections. Mammal dissection training was provided to ensure that both EC and the community-based monitoring program were using standardized dissection protocols. Collaborations were also initiated with Slave River Delta, NWT communities such as the Deninu K'ue First Nation (DKFN), who have provided 20 waterfowl carcasses from traditional hunting areas.

Data Availability and Results: JOSM - Hunter/Trapper Monitoring sites. Chemical analyses of various wildlife tissue samples performed by Alberta Innovates Technology Futures (AITF) are currently under QA/QC evaluation and will be available in Winter 2015.

WT9. Laboratory Phytotoxicity and Contaminants

Initial Commitment: Vegetation assessments undertaken at up to 10 sites in NWT, northern Alberta and Saskatchewan, including along the Athabasca River and in reference sites and greenhouse exposures to NA_2SO_4, and naphthenic acids.

Actual Commitment: No change

Summary of Activity: Vegetation surveys were conducted at 12 sites in the oil sands region, at varying distances from industrial activities. At each site, all plant species were identified. Soil and plant parts were collected for metals and PAH analysis. Soil was collected from a total 58 sites to conduct a long-term greenhouse studies.

Soil was collected from seven possibly impacted sites and five reference sites near Fort McMurray, Alberta. Each sample was assessed for the presence of heavy metals, PAHs, and NAs. Greenhouse exposures to assess phytotoxicity were completed. The effects of different soil concentrations of selenium ($NaSeO_4$) using 5 plant species were evaluated. A seedbank germination study using soil collected from 12 sites and 48 soil samples (locations across Alberta) obtained.

Community consultation and presentations occurred in November 2012 in Fort Chipewyan at the Peace Athabasca Delta Ecological Monitoring Program (PADEMP) that influenced 2013-14 work plans. A variety of plant species important to First Nation and Métis were collected for contaminants analyses, and for use in plant exposure greenhouse studies.

Data Availability and Results: Metadata for 2013 sampling locations are available from **JOSM - Plant Health and Contaminants Monitoring sites.** Data release is anticipated for Fall 2015, following the completion of additional greenhouse monitoring.

BL1. Core Terrestrial Biodiversity Monitoring

Initial Commitment: Fully implemented biodiversity program across 20x20km regularized grid with site visits every 5 years. Fully monitored area includes 3 oil sands areas (Athabasca, Cold Lake, Peace) and all areas within the Lower Athabasca regional planning area (up to 90-100 sites/year)

Actual Commitment: ABMI core program

Summary of Activity: A total of 83 terrestrial and 82 wetland sites were monitored in 2013-2014. The ABMI measures and reports on the status and trends in land, wetlands and living resources across the JOSM region. This entails measurement and reporting on more than 2000 species and habitats at 565 sites across the JOSM region. Data are collected and managed on mammals, birds, plants, moss, lichens, soil mites, habitat and human footprint. A wall-to-wall vegetation and footprint inventory were completed and updated in March 2014. Air photo interpretation for 120 3kmX7km high resolution sites including the ground sites was completed. New protocols for mammals (cameras) and birds (automated recording units) were developed for testing in 2014-15. Vascular plant and bird identifications were completed in winter 2014, while mosses and lichens were somewhat delayed to fall 2014. Access to 2014-15 sites was secured in March 2014.

Data Availability and Results: ABMI.

BL2. Core Terrestrial Biodiversity Monitoring

Initial Commitment: Periodic population or trend assessments of key provincial species (e.g., moose, deer, wolf).

Actual Commitment: Enhanced moose and deer monitoring

Summary of Activity: Three aerial ungulate surveys were completed in WMUs 511, 515/651/841, and 726 within the oil sands region between January 5, 2014 and February 26, 2014. Surveys were conducted using distance sampling methods surveying randomly selected north-south transects and recording detailed observations of moose and deer (age, sex, and antler class), plus additional information including crown closure, activity, snow cover, light intensity and terrain. Population and trend assessment of wolves was not undertaken.

Data Availability and Results: ESRD - Fisheries and Wildlife Management Information System

BL3. Cause-effects Monitoring

Initial Commitment: Cause-effects monitoring of key migratory songbirds and wetland-associated birds.

Actual Commitment: No change.

Summary of Activity: Landbird surveys were conducted across 39 habitat classes where data was lacking. Point count surveys and recordings were used at 3615 locations across the three oil sands deposit areas to improve models of avian response to habitat and industrial footprint. Modelling was used to: (1) explore the importance of spatial scale and role of edge effects in quantifying the effects of energy sector on landbirds, and (2) characterize the community structure and niche characteristics of landbirds to identify habitat specialists and generalists. Conceptual models for pathways of environmental effects on birds were also completed from ecosystem through species scales.

Data Availability and Results: JOSM - Cause-effects Monitoring. Initial model results indicate patch clearing, vegetation extraction, water management, and linear clearing had the most important influence on regional bird populations. Current levels of forestry and agriculture were rated most influential on regional bird populations. These results informed the development of monitoring plans for 2014-2015.

BL4. Cause-effects Monitoring

Initial Commitment: Initial predictions of avian response to current and future land-use

Actual Commitment: Cause-effect of key migratory bird species, waterfowl and other species

Summary of Activity: Updated models of landbird response to habitat and footprint, incorporating existing and newly collected avian data and new geospatial covariates, were developed for 77 landbird species. Population estimates and maps were created for species distribution across the Joint Oil Sands Monitoring study area based on both current land-use and using an estimate for the same landscape with all industrial footprint removed.

To assist with cumulative effects analysis, two recent case studies and five different landscape tools were evaluated, including: A Landscape Cumulative Effects Simulator (ALCES), Cumulative Regional Effects Analysis Tool (CREATe), Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST), Marxan and NetLogo. The assessment considered cost, technical requirements, disturbance types supported, and data requirements.

Data Availability and Results: JOSM - Cause-effects Monitoring

BL5. Measurement Harmonization

Initial Commitment: On-going system to coordinate biodiversity monitoring efforts by industry and other stakeholders into the core biodiversity monitoring program.

Actual Commitment: No commitment made.

Summary of Activity: No funds were allocated to this element for 2013/14. The information below describes activity under a closely related element that contributes strongly to the intent of this measurement harmonization element.

In 2013-14, automated recording units were further tested as a monitoring tool for a range of vocalizing species in on-lease compliance programs as well as at subset of core monitoring sites. Recorders were deployed in the same layout at all these sites, and data were processed and stored by the project team using standardized methods and a centralized database. Automatic recognizers were built for some target species to improve processing efficiency. The project team formed a Yellow Rail Working Group and coordinated Yellow Rail surveys across 4 different organizations.

Data Availability and Results: EMCLA

BL6. Measurement Harmonization

Initial Commitment: Development of standard protocols and processes for monitoring efforts in the oil sands areas for boreal songbirds

Actual Commitment: Promotion of common data standards and protocols

Summary of Activity: Protocols were developed for landbirds for field preparation, training, data collection and data entry and verification.

Data Availability and Results: N/A

BL7. Species at Risk (SAR) and Rare/Difficult Species Monitoring

Initial Commitment: Surveys of boreal woodland caribou

Actual Commitment: Enhanced woodland caribou monitoring

Summary of Activity: The Cold Lake caribou range within Alberta was surveyed in January, February and March 2014. In coordination with ESRD's provincial caribou program, 925 caribou fecal pellet samples were collected from 98 sites for DNA analysis from the Cold Lake caribou range. Additional work included: capture and radio-collaring of 120 boreal caribou in oil sands region, recording of adult female caribou survival and estimation of annual mortality rates, determination of caribou calf survival and calculation of annual population growth rates for each boreal caribou population.

Data Availability and Results: ESARD - Fisheries and Wildlife Management Information System. DNA processing and analysis is on-going and a report will be publically available when complete.

BL8. Species at Risk (SAR) and Rare/Difficult Species Monitoring

Initial Commitment: Monitoring of Whooping Crane

Actual Commitment: No change.

Summary of Activity: 44 cranes were marked with satellite transmitters and monitored. Ten adult cranes were marked with satellite transmitters by our partners in Aransas National Wildlife Refuge in winter 2013/14.

Data Availability and Results: JOSM contributes to a larger collaborative study, to be completed by 2019. All data will be made available at the conclusion of the collaborative study in 2019.

BL9. Species at Risk (SAR) and Rare/Difficult Species Monitoring

Initial Commitment: Full implementation of status and trends and cause-effects monitoring for other key provincially and federally listed species and improved monitoring for rare/difficult to detect species.

Actual Commitment: No commitment for monitoring made for 2013-2014.

Summary of Activity: Developed a monitoring program for old forest species, including the following rare species or species at risk: Canada warbler, Black-throated green warbler, Cape May warbler and Bay-breasted warbler. Monitoring was initiated May 2014.

Data Availability and Results: No data are available.

BL10. Species at Risk (SAR) and Rare/Difficult Species Monitoring

Initial Commitment: Implementation of specialized protocols for collecting data on key provincially and federally listed species.

Actual Commitment: Other provincial and federal SAR species monitoring and federal wetland SAR monitoring and design monitoring protocol for: Barred owl, Northern Long-eared Bat, Canadian Toad.

Summary of Activity: For old forest bird species, sampling design and protocols were developed in support of a monitoring program for these rare species. Protocols were developed for landbirds including field preparation, training, data collection and data entry and verification.

Barred owl detections were recorded using a call playback method at 579 randomly generated survey sites across various levels of barred owl habitat suitability. Between March 18 and April 17, 2013, 495 sites of the 579 randomly generated sites were surveyed once and 386 of these sites were surveyed twice. GPS dataloggers were attached to captured owls in areas across the oil sands region. Twelve GPS dataloggers were deployed in April and May; data were successfully downloaded from two owls for a total of 31 locations.

Data Availability and Results: A total of 41 owls were detected during the occupancy surveys. Barred owl occupancy and location data: **ESARD - Fisheries and Wildlife Management Information System.**

BL11. Species at Risk (SAR) and Rare/Difficult Species Monitoring

Initial Commitment: Implementation of specialized protocols for collecting data on key provincially and federally listed species. Coordinated data collection of priority provincially and federally listed species.

Actual Commitment: Rare Plants Project: Field planning and data collection; analyze and report on field data; prepared phase II of pilot project. Rare Animals Project: Field planning and data collection (yellow rail, amphibians, and owls); analyze and report on field data; prepare phase II of pilot project. Monitor other provincial and federal species at risk monitoring.

Summary of Activity: Plant inventories were conducted at over 200 sites using an adaptive sampling approach, resulting in over 9000 plant observations on 450 different species. Analysis was conducted on importance of survey length in vegetation surveys. Recorders were deployed at 42 sites for owls, 27 sites for amphibians, and 65 sites for Yellow Rail. Over 2.5 years of recorded sound data was collected. Camera data was gathered from crossing structures to determine actual crossing rate of caribou for validation of the movement study. Analysis was completed and manuscript prepared in the fall of 2014.

A pilot project was initiated with the community of Fort Chipewyan to monitor Yellow Rail in the Peace Athabasca Delta. Elders' knowledge of the delta was used to choose locations to deploy automated recording units and training was provided to community members to deploy the recorders.

Data Availability and Results: One hundred and fourteen new rare plant observations were made. 129 animal species were detected, including over 60 new Yellow Rail detections. Habitat analysis indicates graminoid fens and meadow marshes are important for Yellow Rail. **EMCLA**

BL12. Human Disturbance Footprint Monitoring

Initial Commitment: Development and implementation of wall-to-wall footprint mapping (extension from panels) with continued refinement.

Actual Commitment: Common protocols and footprint mapping

Summary of Activity: Updates to the 2010 wall-to-wall human footprint GIS layer to 2012 conditions is ongoing, with a website release planned for late 2014. Enhanced accuracy of Government of Alberta base features (cutline, pipelines and roads) in human footprint layer for the oil sands region was incorporated as part of GOA Base Features and is to be included in the 2012 wall-to-wall human footprint layer. Information was provided to report on status of human footprint in oil sands region including change in human footprint between 2000 and 2012 based on the 3x7 km samples throughout the JOSM region. Protocol refinement and QC to better track trends in human footprint were initiated.

Data Availability and Results: Updates to wall-to-wall human footprint layer are available from ABMI.

BL13. Human Disturbance Footprint Monitoring

Initial Commitment: Refinement of footprint types for key provincial species, forest songbirds and species at risk

Actual Commitment: Common protocols and footprint mapping

Summary of Activity: Revised human footprint types incorporated and methods used to model species-habitat associations. Detailed classes of human footprint were determined and summarized for field sites visited during 2013/14, and for all quarter sections in the JOSM region. Some incorrect cutblock boundaries were corrected during 2013/14 and cutblock age was completed June 2014. An NSERC collaborative research and development project to test methods for monitoring vegetation recovery was developed during 2013/14.

Data Availability and Results: Updates to wall-to-wall human footprint layer are available from ABMI.

BL14. Habitat Monitoring

Initial Commitment: On-going augmented program to collect vegetation and other ground-based habitat data.

Actual Commitment: Common protocols and footprint mapping

Summary of Activity: Developed Primary Land Vegetation Inventory request, awarded contract and had inventory completed for 56 townships within the oil sands region that was previously unmapped. On the ground habitat data collected at 79 sites.

First Nations and Métis community members often accompanied the monitoring crew.

Data Availability and Results: Ground habitat data for each site are available from ABMI.

BL15. Habitat Monitoring

Initial Commitment: On-going augmented wall-to-wall land cover mapping. Continue work to assess potential of remote-sensed and high-resolution photo data for biodiversity prediction. Assess ability to interpret and classify data sources to provide key habitat features relevant to key species that are the focus of cause-effects monitoring.

Actual Commitment: Common protocols and footprint mapping

Summary of Activity: Combined existing wetland layers to create an oil sands region wetland map and combined existing vegetation layers to create an oil sands region vegetation map.

For biodiversity prediction: initiated discussion with organizations in Alberta to develop a vegetation monitoring initiative that builds on new remote sensing imagery and tested methods to extract ecosite information based digital elevation models.

Data Availability and Results: ABMI

BL16. Habitat Monitoring

Initial Commitment: Through species-habitat modelling, identify key sources and sets of land cover, productivity, climate and other biophysical variables required for biodiversity prediction.

Actual Commitment: No commitment

Summary of Activity: Modeled species-habitat relationships to identify land cover and biophysical information for: mammals, birds, vascular plants, mosses, lichens and mites. Information about climate, soils, and vegetation increased the prediction strength of the models.

Data Availability and Results: ABMI

BL17. Habitat Monitoring

Initial Commitment: Continue building library of land cover, productivity, climate and other biophysical data layers required for biodiversity prediction.

Actual Commitment: Common protocols and mapping

Summary of Activity: Used publically available GIS information to create GIS layers describing climate, topography, and soils throughout Alberta's oil sands region and converted them into raster images.

Data Availability and Results: ABMI

Abbreviations

Organizations

ABMI	Alberta Biodiversity Monitoring Institute
AEMERA	Alberta Environmental Monitoring, Evaluation and Reporting Agency
AER	Alberta Energy Regulator
CCME	Canadian Council of Ministers of the Environment
EC	Environment Canada
ESRD	Alberta Ministry of Environment and Sustainable Development
LICA	Lakeland Industry and Community Association
RAMP	Regional Aquatics Monitoring Program
WBEA	Wood Buffalo Environmental Association

Acronyms

CEMS	Continuous Emissions Monitoring System

Chemical Substances

As	Arsenic
Ag	Silver
Be	Beryllium
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
Cd	Cadmium
CO_2	Carbon dioxide
Cr	Chromium
Cu	Copper
DNA	Deoxyribonucleic Acid
Hg	Mercury
NA	Naphthenic Acid
NA_2SO_4	Sodium sulfate
Ni	Nickel
NOX	Oxides of nitrogen
PAC	Polycyclic aromatic compounds
PAH	Polycyclic aromatic hydrocarbons
Pb	Lead
Sb	Antimony
Se	Selenium
SO_2	Sulphur dioxide
TGM	Total gaseous mercury
Tl	Thallium
VOC	Volatile organic compounds
Zn	Zinc

Joint Implementation Plan for Oil Sands Monitoring - Results Report 2013-2014.

Plan de mise en œuvre conjoint pour la surveillance visant les sables bitumineux : rapport des résultats 2013-2014.

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TTY: 819-994-0736
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